

Wind Power and Diversified Renewable Energy Portfolios

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This presentation

- Background
 - Variability

- Resource characteristics
 - Demand patterns
 - Wave
 - Tidal stream

- Backup
 - Different estimates
 - Possible reasons

- Relationships
 - Between renewables and demand
 - Between different resources

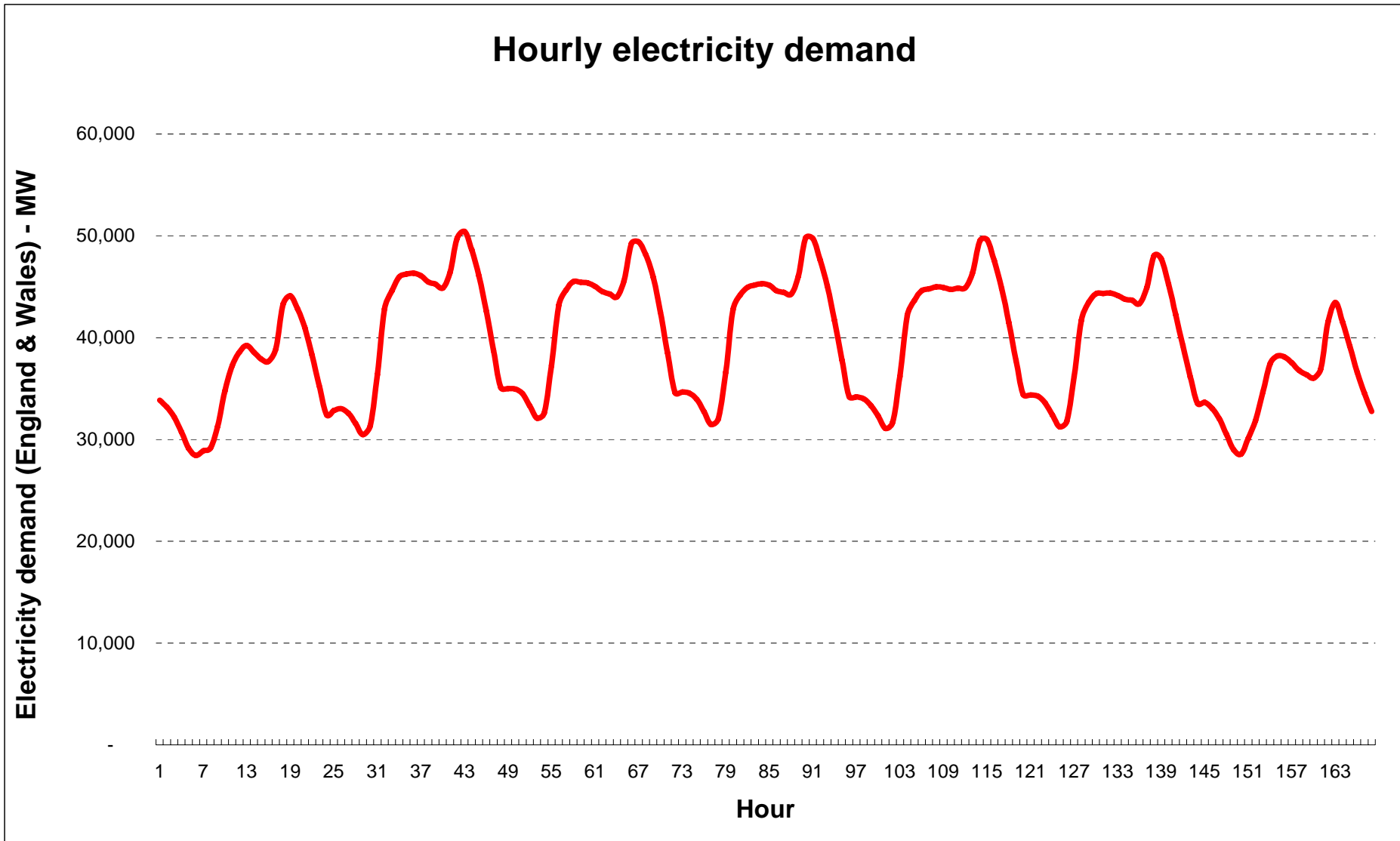
- A diversified renewable energy strategy

Background - variability

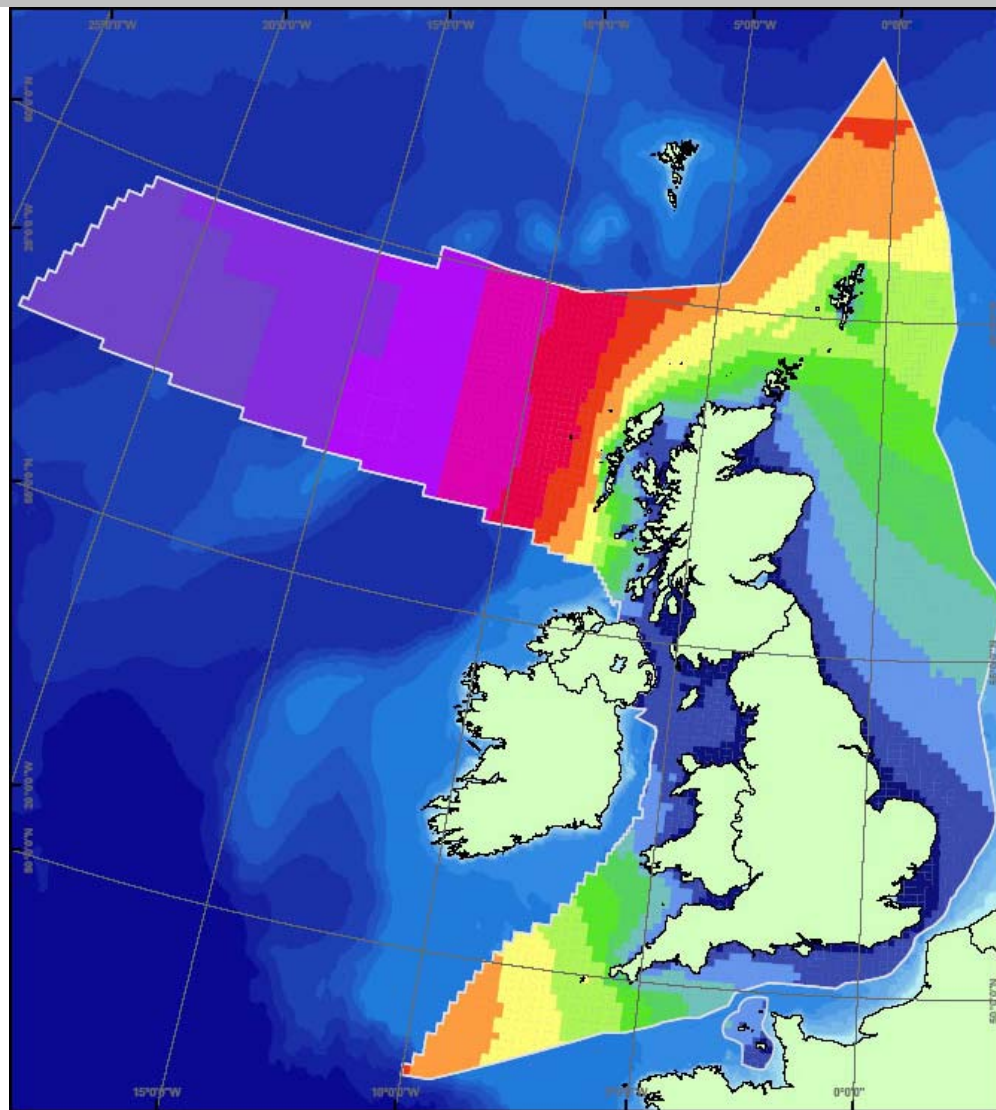
- Different renewable resources have different patterns of variability
- Variability occurs at different time scales
 - Years
 - Seasons
 - Months
 - **Hours**
 - Seconds
- Demand also varies!

Resource characteristics

Electricity demand varies over time

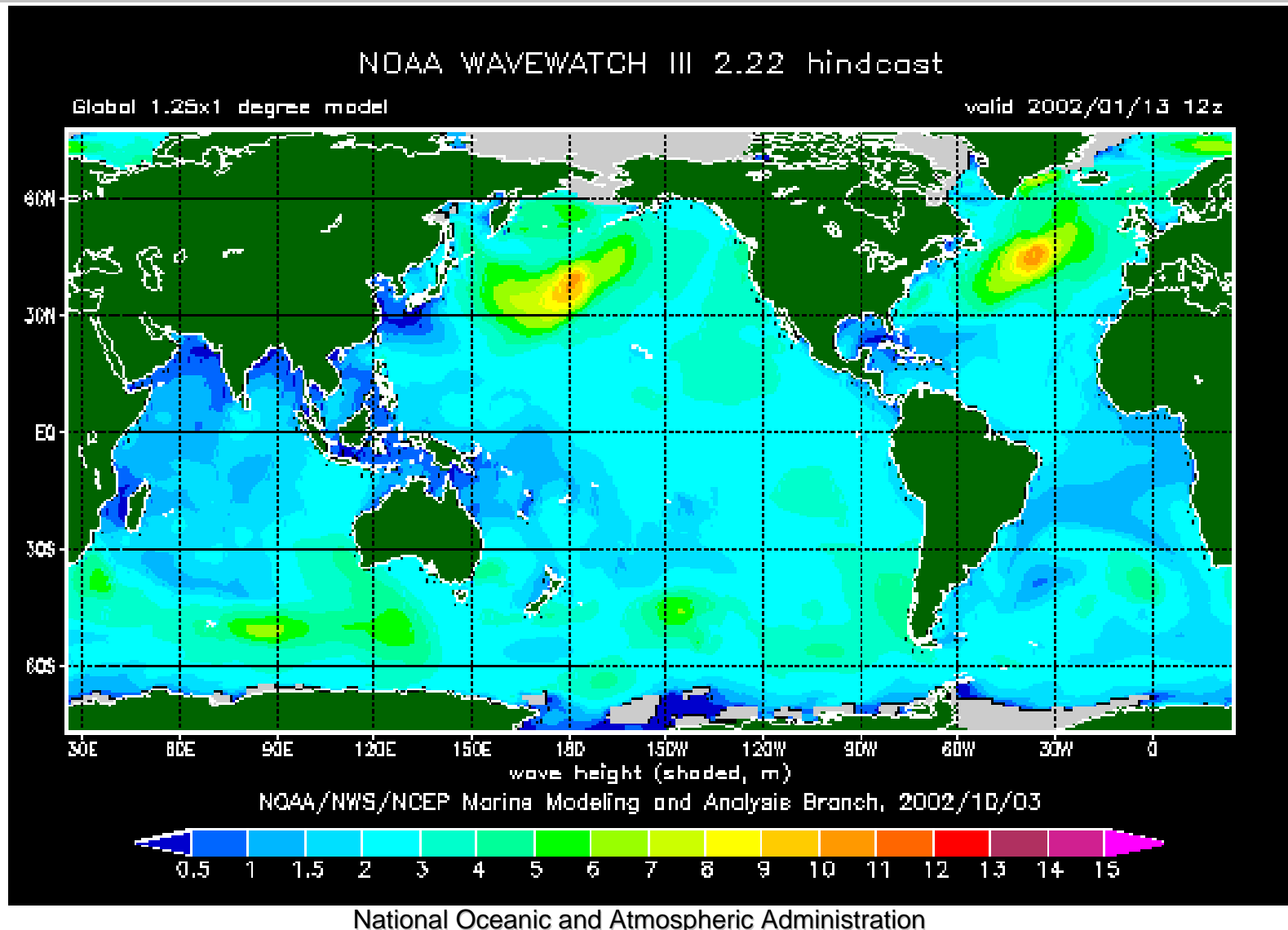


The UK has a wide expanse of high energy wave areas



DTI: Atlas of UK Marine Renewable Energy Resources

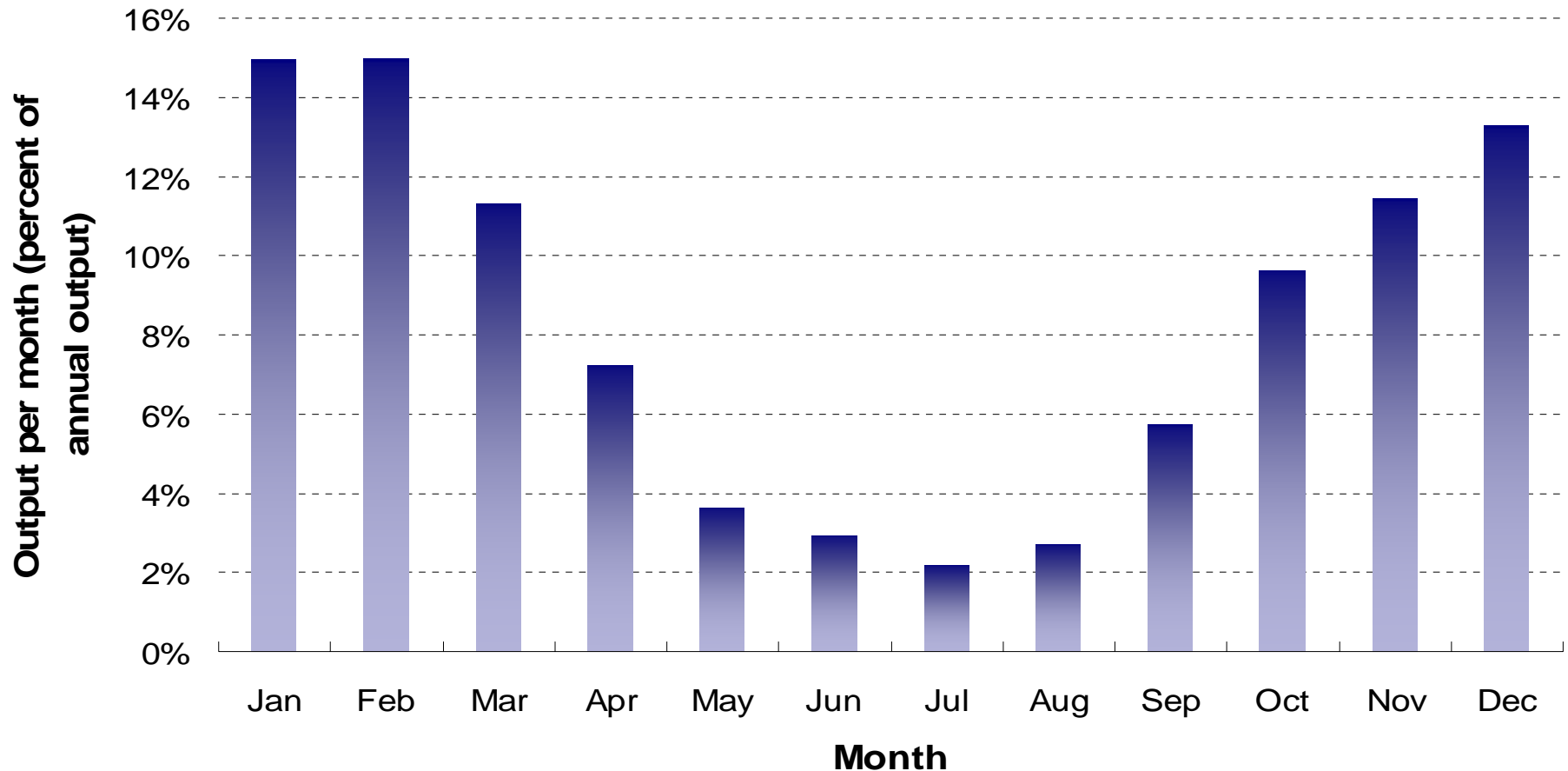
Wave power varies over time and by location



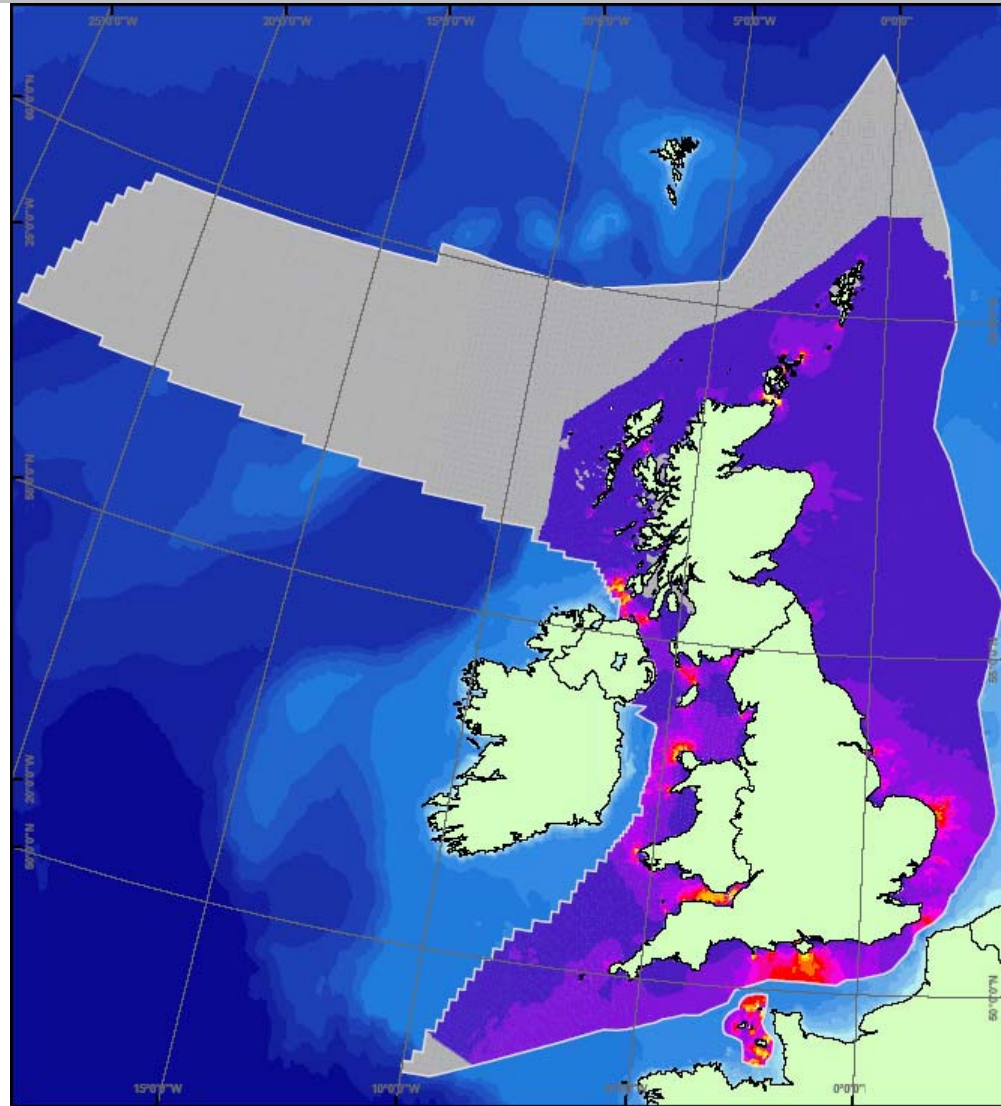
December, January and February see most wave power in the UK

Monthly Distribution of Wave Power Generation

(Sites from the North East, North West and South West Regions - unweighted between sites - generic Pelamis power transform - 1988 to 2004)

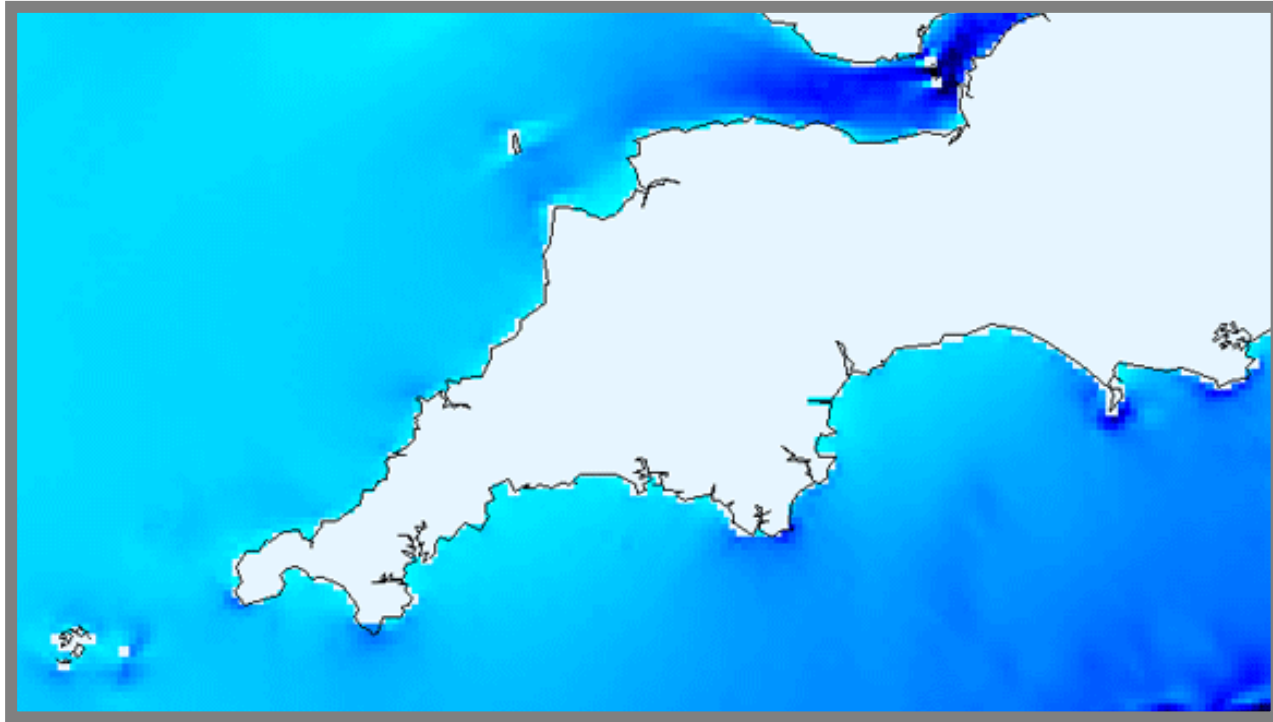


Tidal stream power is available in a range of locations around the UK



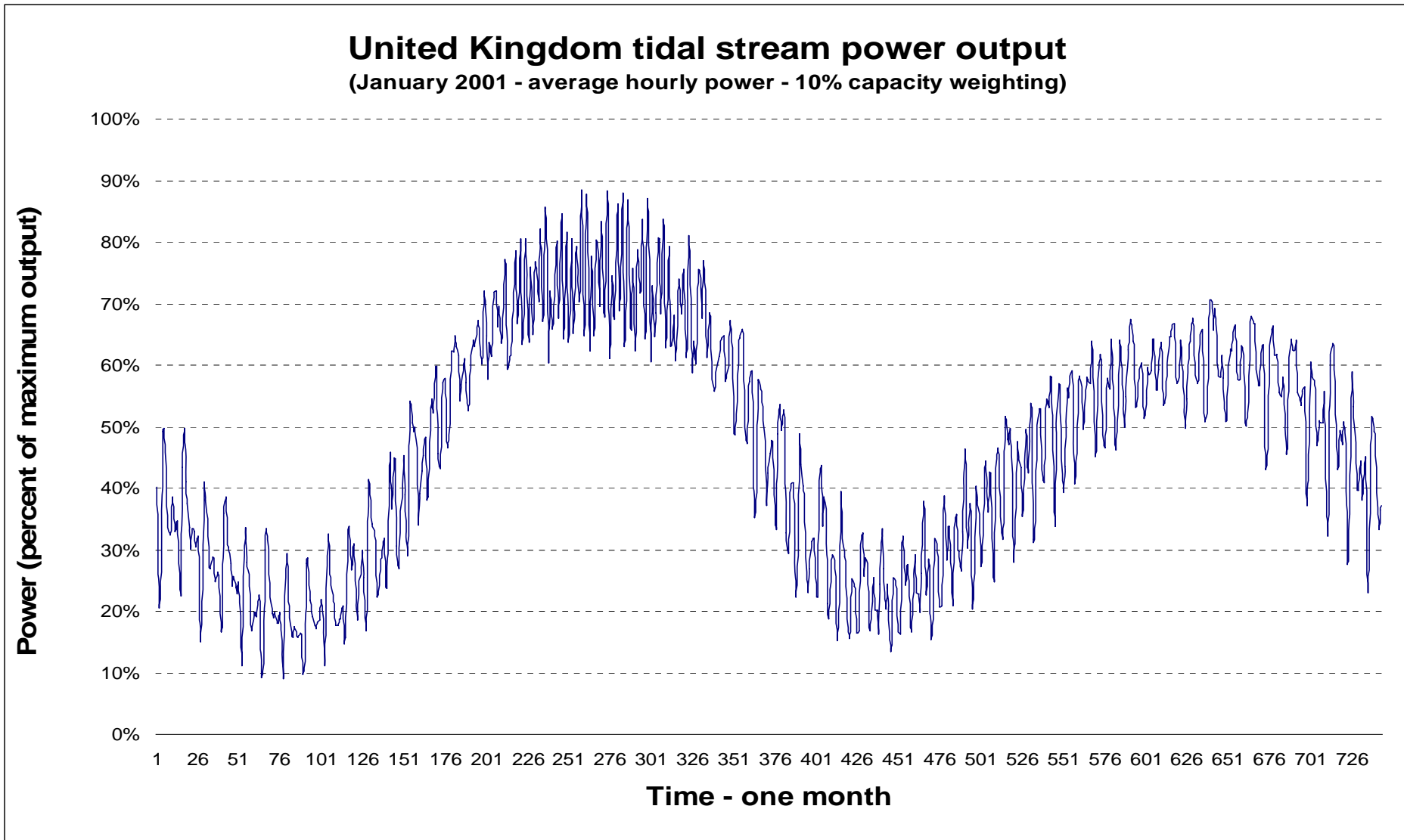
Source – DTI: Atlas of UK Marine Renewable Energy Resources

Tidal stream power varies over time, and by location



Base Data – POL CS20 Model

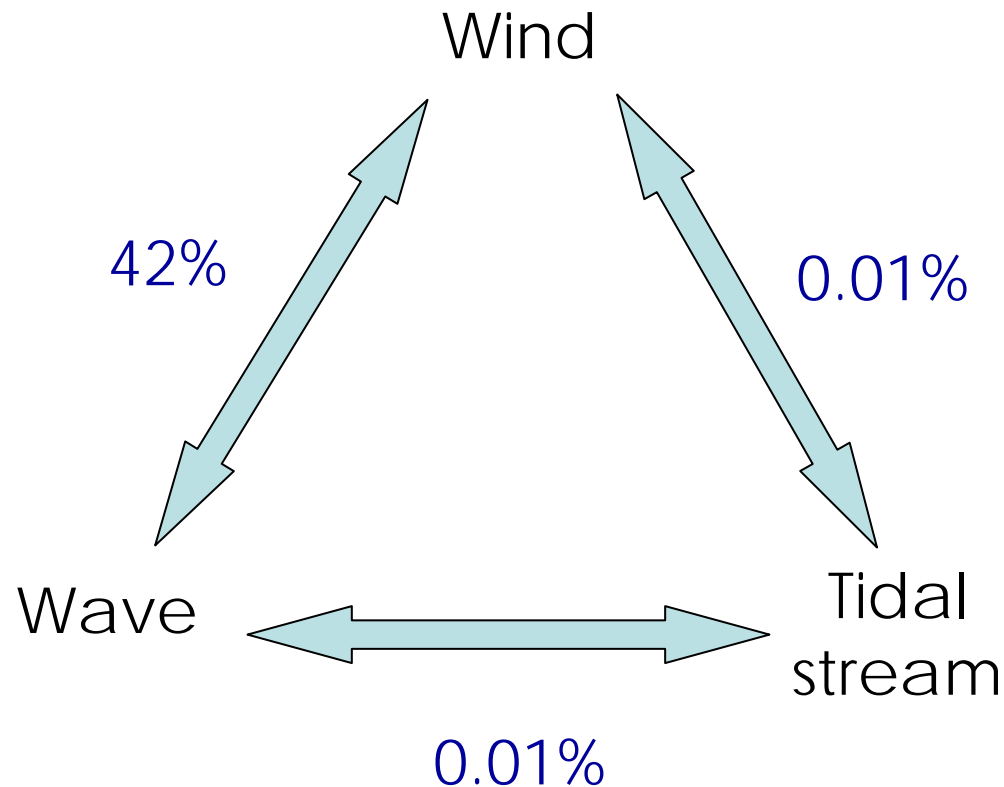
Hourly and 14-day patterns of variability in tidal stream energy



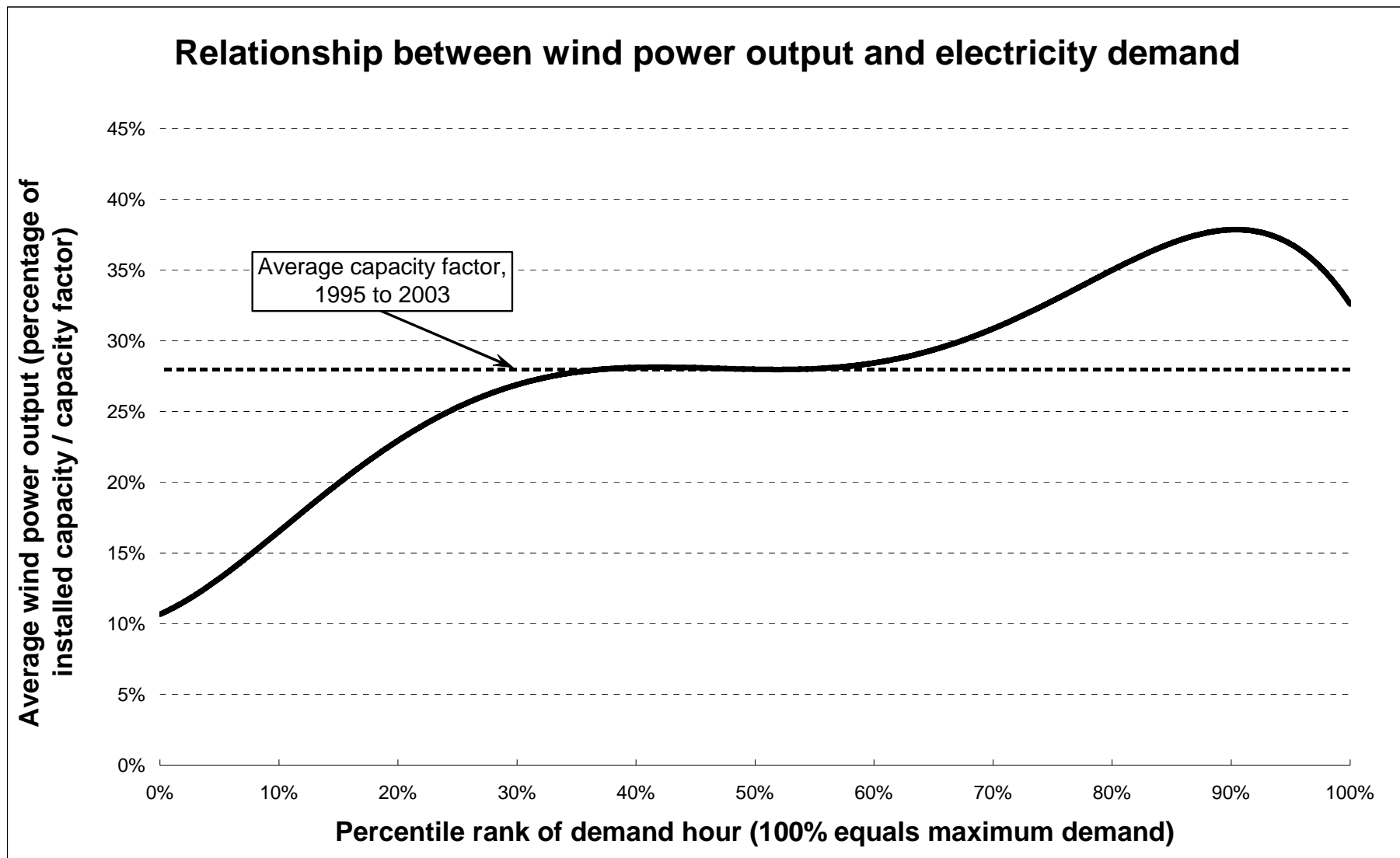
Relationships

The correlation between different renewable resources

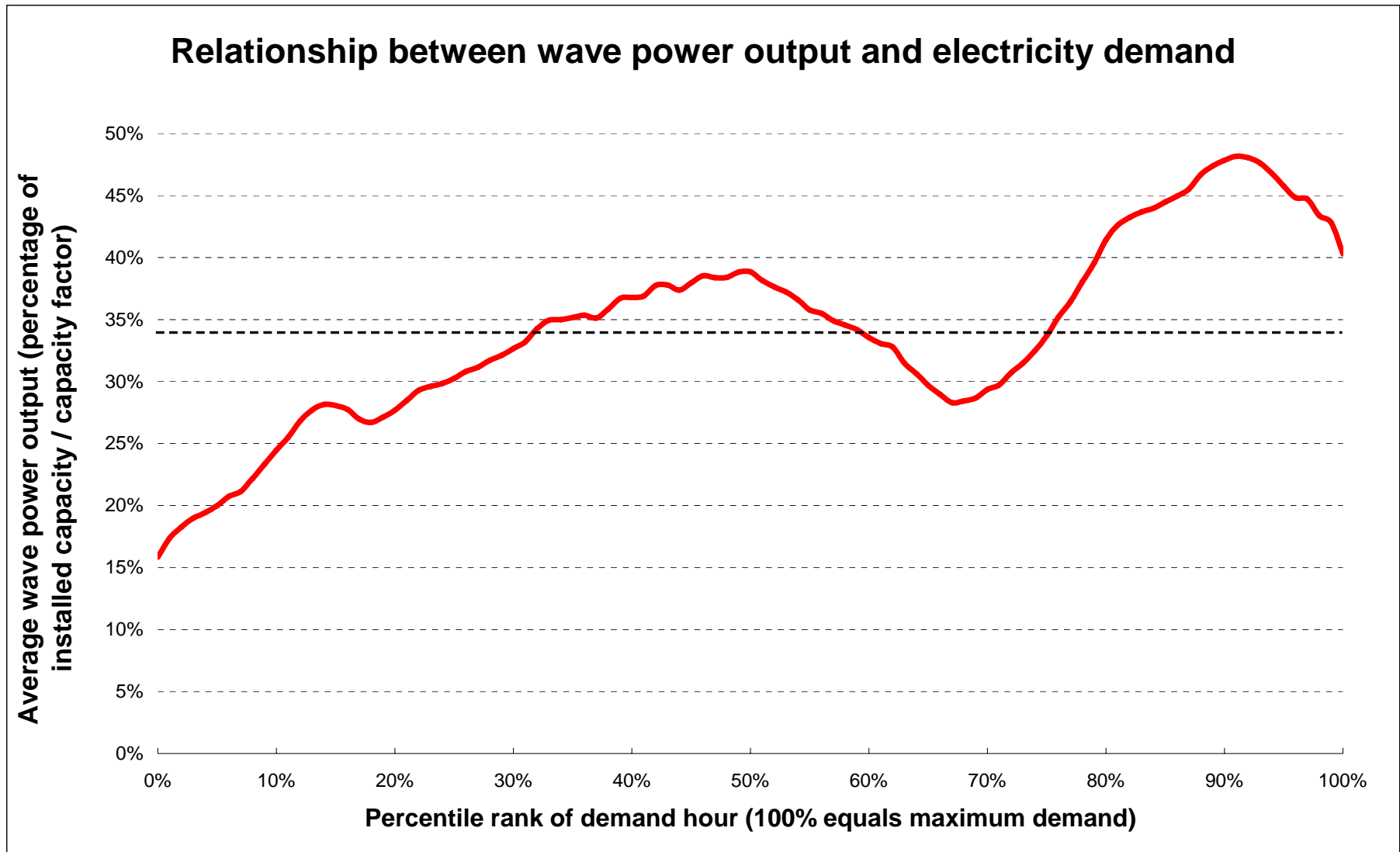
Correlation (r^2) of power output patterns



Wind power delivers more energy at times of high electricity demand



Wave power delivers more electricity at times of high demand



Backup

Backup as a percentage of installed wind capacity

Authoritative reports based on sound methods and analyses found...

17%	Dale, Milborrow, Slark & Strbac (2004)
15%	House of Lords (2004)
12%	ILEX (2003) (slightly lower penetration scenario)

Reports based on opinion or flawed methods found...

100%	Adam Smith Institute
100%	Prof Michael Laughton
100%	Country Guardian
73-86%	Royal Academy of Engineering
65%	PB Power / R.A.Eng.

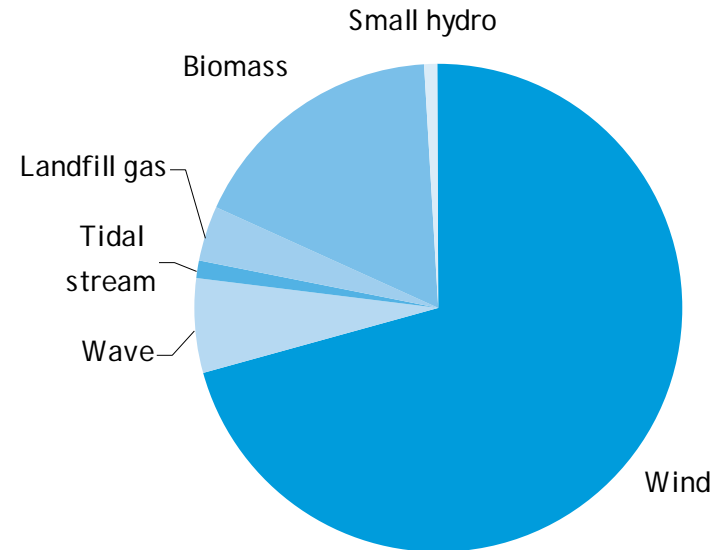
Why are some backup estimates so extreme? Maybe...

- Inappropriate models for assessment;
- Different treatment of wind and conventional capacity;
- Poor understanding of the properties of renewable resource;
- Evaluation of different scenarios;
- Results driven by personal beliefs rather than factual analysis;
- Vested interests.

Diversified portfolios

Diversification - scenarios

- Renewable energy scenarios matter!
 - What proportion of total electricity generation?
 - What proportion of renewable electricity generation is from variable resources?
 - What mix of variable resources are included?
- Example – the Renewable Networks Impact study (Carbon Trust, 2004)
 - 20% of demand met by renewable electricity by 2020
 - Around 75% of the renewable electricity supplied by variable resources
 - Range of renewable resources – wind, wave and tidal stream



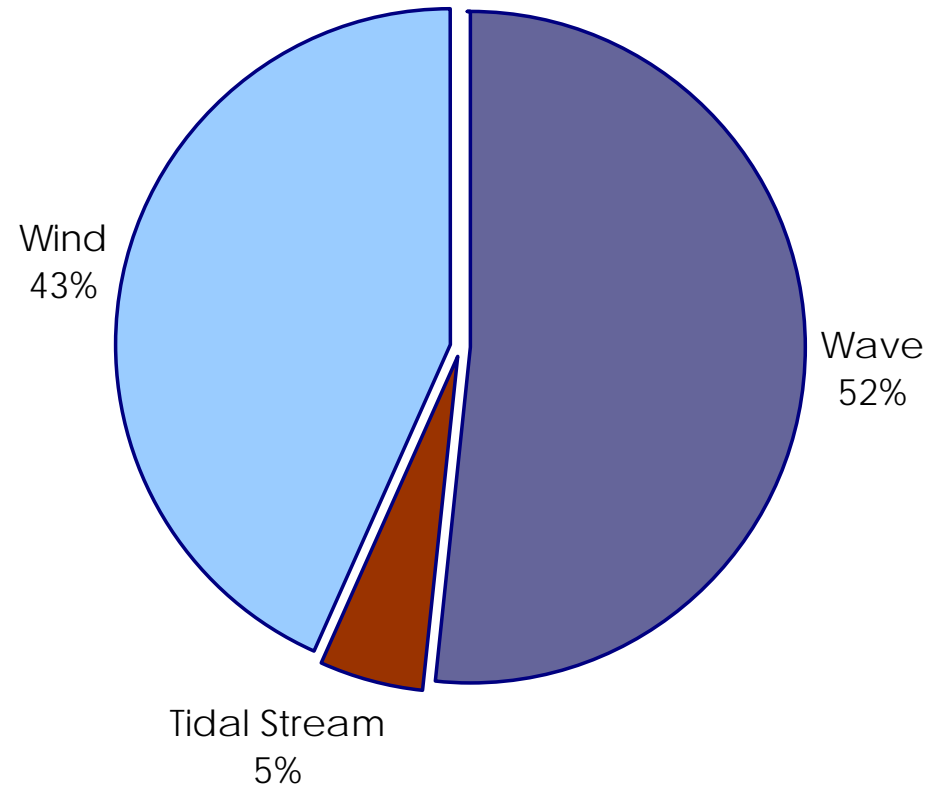
Diversified portfolios

- Different resources, different properties
- Different resources, different relationships with demand

- Can these different properties of different renewable resources be combined so that a “better” result is achieved?

A diversified portfolio – UKI scenario

- Wind power – range of sites throughout the UK.
- Wave power – range of sites in three high-energy coastal regions in northern and south-western UK.
- Tidal stream power – range of sites throughout the UK.
- **The contribution of different sites and resources was modelled to achieve low variability in the overall renewable energy supply.**



Diversified portfolios lower variability

- The variability of the renewable electricity supply profile shows the degree to which electricity output changes from hour to hour.

Renewable supply	Variability – percent of installed capacity
Tidal stream power only	6.3% - 22.4%
Wind power only	3.2%
Wave power only	2.6%
UKI scenario	2.0%

Diversified portfolios improve capacity credit

- Capacity credit measures the extent to which renewables can reduce the need for conventional capacity. In this scenario, 20% of UK electricity demand is met by wind, wave and tidal stream power.

Scenario	Conventional Capacity	Capacity credit
Conventional system	84GW	- - -
Wind-only scenario ¹	79GW	5GW
UKI scenario	76GW	8GW

1 – from Dale et al, 2004

Diversified portfolios reduce balancing costs

- Balancing cost arise from the need to respond to changes in renewable output – by reducing the variability of the renewable electricity supply, the additional balancing costs are also reduced.

Scenario	Additional balancing cost
Wind-only scenario ¹	£2.85/MWh
UKI scenario ²	£1.80/MWh

1 – NGC data, reported in Mott MacDonald (2004)

2 – Analysis by David Milborrow

Acknowledging the benefits

- Diversity of generating capacity – diversified systems are inherently more reliable, and renewables bring diversity.
- Energy independence – at a time when the UK is moving very quickly towards energy dependence, renewables offer true independence.
- Price independence – fuel prices are set by global energy markets. The cost of generating electricity from many renewables is independent of fuel price.
- Energy Availability – imports of fuels may be interrupted for a variety of reasons. What geopolitical event will affect the wind, stop the waves hitting the shore, the sun from rising, or the tide rising and falling?
- Carbon Costs or Sequestration – carbon costs are likely to rise, while sequestration will always represent a net additional cost to fossil fuels; renewables are independent of these costs.

The end

We are happy to acknowledge and thank the following organisations for providing data used in this work:

UK Met Office
British Atmospheric Data Centre
Proudman Oceanographic Laboratory
National Grid

Part of this work was commissioned by the Carbon Trust as part of the Marine Energy Challenge.

For further information on UK renewable resource characteristics visit:
www.eci.ox.ac.uk/energy

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